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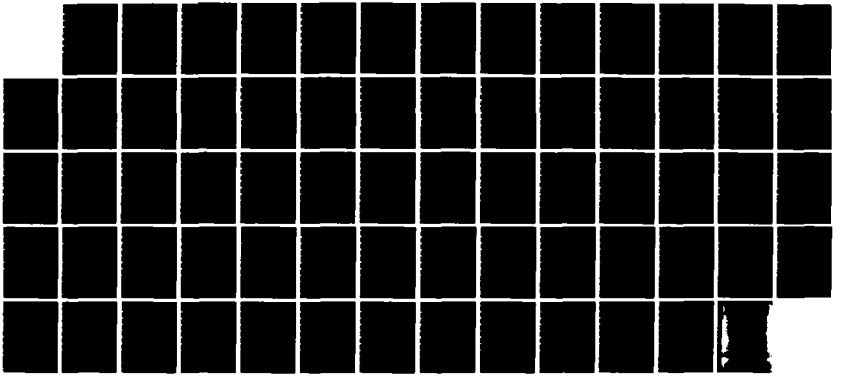

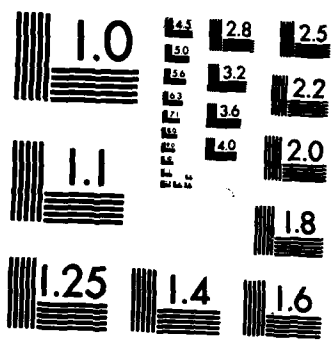

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THE DESIGN OF AN EXPERT SYSTEM FOR CONTRACT PRICE ANALYSIS

Drs. B. Chandrasekaran, J. Dillard,
and K. Ramakrishna
Department of Computer and Information Science
The Ohio State University
Columbus, Ohio 43210

30 September 1983

Interim Report for Period Covering 15 July 1983 - 30 September 1983
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This report discusses the feasibility of designing an expert system for contract price analysis. It recommends an intelligent manual for base-level procurement be implemented. Also presented is a prototype design in the ZOG information management system. The system architecture and the organization of pricing knowledge in the system was determined by field investigations. The pricing task is a relatively small component of the total procurement task. This coupled with the distributed nature of the information needed for price analysis render the implementation of a more complex, self-contained expert system infeasible at the present time. Also discussed are implications for future research and the limitations of the proposed design. Several alternative designs are evaluated.

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System for Price Analysis

ABSTRACT

This interim technical report describes the work performed in Phase III of Contract F33615-82-C-5114 covering the period 1 May 1983 to 30 September 1983. As a result of this investigation, we recommend that an intelligent manual expert system be implemented to assist in the price analysis phase of the procurement process. This recommendation is based upon:

1. A review of training programs and authoritative publications.
2. Briefings, interviews and case analyses performed by personnel from three Air Force procurement organizations.
3. An evaluation of three alternative system designs.

A prototype intelligent manual was constructed using ZOG, an information organization system. The system architecture was determined by a task analysis of the pricing task. The pricing task was identified by field investigations and was found to be a relatively small component of the procurement task. This coupled with the distributed nature of the requisite information render implementation of a more complex, self-contained expert system infeasible at the present time. Even though the intelligent manual lacks decision-making capabilities, its implementation would allow data to be gathered and technology to be developed and disseminated that would be necessary for constructing more self-contained systems.

The implications for future research such as human interface issues and system application and extention are discussed. The limitations of the recommended approach such as the inability of the system to draw inferences from prior decisions and the restricted focus of the study are identified and several alternative designs are evaluated.

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1. INTRODUCTION

1.1 Summary of Prior Report

The previous technical report described the work accomplished during Phases I and II of this project (covering the period from 1 October 1982 to 30 April 1983). It contained conclusions about the feasibility of expert systems for price analysis, provided an analysis of contract pricing, discussed the preliminary design of an intelligent manual, and briefly surveyed the educational environment within the Air Force. The report identified problems associated with price analysis during procurement and discussed the feasibility of designing an "expert system" using techniques from the field of artificial intelligence. The analysis suggested that an "intelligent manual" type of expert system would be most useful. The maximum benefit of this system would be felt in base-level procurement.

The design of a prototype of the intelligent manual in an information base called XINFO[1] was presented. The problems with this design were discussed and an initial redesign using another information organizing system called ZOG[2] was presented.

1.2 Preview of this report

This technical report describes the work accomplished during Phase III of the project. In addition, we report on activities performed as part of Phases I and II not previously reported.

These activities include:

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[1]XINFO is not an abbreviation; the name is intended mainly a mnemonic for the extended information base capabilities of the system.

[2]ZOG is not an abbreviation, either. The name ZOG was chosen to represent the novelty of the ZOG style of human-computer interaction.

1. Interviews and briefings with procurement personnel designed to identify existing Air Force data bases (as required by the Statement of Work (SOW) 4.1.2.4).

2. Defining and documenting rules and experience used in the Air Force (SOW 4.2.2).

3. Developing a model of the methodological approach used by the Air Force procurement personnel based upon the findings (SOW 4.2.1).

The tasks performed during Phase III reported herein include:

1. Developing the expert computer system using the knowledge base developed during the data gathering phase (SOW 4.3.1).

2. Building a demonstration prototype of the system within the ZOG framework (SOW 4.3.2).

3. Defining areas of future research and identifying limitations of the proposed system (SOW 4.3.3).

4. Discussing alternative system designs (SOW 4.3.4.).

2. CONSTRUCTION OF KNOWLEDGE BASE (SOW 4.1.2.4)

In this chapter we identify existing data bases in the United States Air Force (USAF) that may be used in analyzing contractor cost and price proposals. We define the scope of these data bases and their uses in the contract pricing environment.

2.1 Current Data Bases

The following online data bases related to the procurement process were identified:

1. CIAPS -- used at the base level. This database contains a classified index of items purchased in the past and contains information about prior buys as well as local dealers and manufacturers of the item.

2. J041 — used by the Air Logistics Command. This database is largely a management tool used to track the activity of the procurement section with respect to individual purchases.

3. Government Services Administration schedules — These schedules document agreements between a large number of contractors and the US Federal government as a whole. Since these schedules specify prices, the buyer can use them as a substitute for obtaining an actual quote.

4. Price indices — These are usually issued monthly and annually by the Department of Commerce and are specific to different areas of the country. They can be used to adjust historical pricing data.

5. On-site databases — provided to the Air Force Systems Command and the Defense Logistics Agency (DLA). AFPRO and DLA representatives at the contractor's manufacturing site have access to historical and current information about the contractor's actual costs and practices. This is useful for evaluating sole-source proposals.

6. AMIS — used by Air Force Systems Comamnd. This system (Acquisition Management Information System) provides detailed, historical procurement information on over 61,000 contracts as well support for contract preparation and report generation.

These are historical data bases that contain some procurement history on

prior buys. To the extent that historical information is useful in establishing a government position, these data bases are useful. However, their usefulness is degraded by the time lapsed between the last purchase and the current one, by the inability to identify the same or similar items within the system, by the time it takes to get the prior procurement into the system, and by the low commitment of personnel to maintaining these systems. Prior contract files maybe available in hard copy but they are neither easily accessible nor consistently documented.

The Contract Data and Management Systems (CDMS) section in the Air Force Logistics Command appears to be in the process of implementing a coordinated data base management program that will incorporate and replace the current data management programs for Air Force Logistics Centers (ALCs). This system would provide the historical procurement data on-line to all ALCs.

The base level buyers use the historical information as the primary basis for their objective price if it is available and if they have no disconfirming evidence. Air Force Logistics Command (AFLC) buyers use historical cost as a last resort for establishing an objective price because of the dynamic nature the procurement environment. Air Force Systems Command (AFSC) analysts are generally leery of using historical costs because of the technological environment and the uniqueness of most of their procurements.

2.2 Interviews and Briefings (SOW 4.2.1)

In this section we describe the procedures and techniques followed in defining the Air Force experts' knowledge base.

The following interviews were undertaken in addition to those reported in the first Technical Report.

1. The research group met with Mr. Rollie McReynolds of AFLC at AFLC Headquarters, Wright-Patterson Air Force Base (WPAFB). The

in-depth interview covered issues with respect to automation of the AFLC buying activities and Mr. McReynold's reaction to a set of base-level pricing cases. The topics discussed included the Pacer Price program, provisioning and replenishment spares procurement, and sampling techniques used in pricing. The primary focus of the meeting was to have Mr. McReynolds evaluate a set of base level pricing cases from two aspects. First, Mr. McReynolds analyzed the cases to determine the adequacy of the case packet. Mr McReynolds evaluated six case packets. The indepth interview was very helpful in identifying the process that a buyer must undertake in evaluating a case and determining the extent of incompleteness of the case packets, and the information necessary to complete them.

2. The research group met with two base level supervisors from the 2750th Air Base Wing (ABW)(Ms. Viola Williams and Mr. Marty Spaare) and with two Air Base Logistics price analysts (Mr. Bill Bower and Mr. Charles Warren) who were responsible for the training of the 2750th base level buyers. Each supervisor and analyst met separately with one member of the research group. During these sessions, they were given case packets, one at a time, and told to "think aloud" while they came to their determination of a fair and reasonable price for the item being purchased. The sessions were recorded on tape and were subsequently transcribed. These sessions provided excellent insight into the base level buying process. The interviews were conducted at WPAFB.

3. The research group received a briefing from Mr. Roy Bondurant, CDMS, AFLC, WPAFB to acquaint them with the current data management capabilities of AFLC and the plans for the future. The current capabilities are not adequate and HQ has initiated programs to correct the deficiencies. The major thrust of these programs is to consolidate data management into one integrated system. The goal of the program is to have the ALCs automated by the mid-1980s with extensive online capabilities. This includes providing buyers with easy access to terminals and suggests that a work station concept is a viable alternative that is currently being considered by the AFLC. If this is the case, it would be feasible to implement an initial version of an intelligent manual as part of such a system. This is a possible way to test our proposed system in a more realistic setting.

4. We met with Base Level personnel from the 2750th Air Wing, WPAFB. We met first with Mr. Bill Bower, a price analyst for the 2750th at WPAFB. We discussed the case packets and the possibility of receiving additional data. He stated that some of the needed data was currently available and he would attempt to find the remainder. He provided us with a list of information supplied to the buyer by the supply system. We next met with Ms. Barbara Walls, Chief, System Management Section,

who has had many years of buying experience and is currently in charge of the Customer Integrated Automated Purchasing System (CIAPS) program. Ms. Walls indicated the information was supplied to the buyer and the portion of that information was provided by an automated data base. The CIAPS system was explained as part of this discussion. She also explained the GSA catalog system and gave a demonstration.

5. Two base level buyers from the 2750th were observed by individual members of the research team as they carried out their work tasks. Each was questioned as to what tasks were being performed and the reasons for the actions being taken. The buyer discussed the cases in which she was currently involved pointing out relevant issues and explaining their anticipated resolution. They were also questioned about the reference material they used and the assistance provided by the price analysts. These interviews were helpful in gaining an appreciation for the environment in which a buyer must work.

6. Professors Dillard and Ramakrishna accompanied by Major Weber, visited buying activities in the San Antonio Texas area. Visits were made to the ALC at Kelly AFB, AF Training Command, Randolf AFB, and the San Antonio Contracting Center. The following activities were accomplished:

   a. Case evaluation sessions with two ALC buyers(Ms. Anita Maldonado and Mr. Billy W. Sullivan) and two ALC price analysts (Mr Earl K. Booth and Mr. Leroy Hassler). These personnel were presented with the cases packets and asked to "think aloud" as they analyzed the cases in an attempt to determine the fairness and reasonableness of the contractors proposed price. The protocols used and the results obtained were similar to those presented above. The ALC procurement activities appeared to be characterized by more buyer specialization and better support. This is the result of the higher dollar values of the buys and the higher volume of specific types of buys.

   b. As was the case with the base level buyers, the two ALC buyers (Ms. Particia Larzelere and Ms. Rita Brown) were observed for the greater part of a day as they carried out their normal daily tasks. This allowed us to identify informal information files and certain heuristics used by the buyer. For example, one of the buyers maintained a file of "unique situations" in which she had been involved. She also maintained items which she perceived to be useful in training new buyers. The importance of considering the total procurement task was pointed up.

c. We received an explanation and demonstration of the new Automated Contract Writing System being installed at the Kelly ALC. The demonstration was conducted by Ms. Margaret Comas.

d. We met with the following contracting personnel in the AF Training Command who were involved in base level procurement: Ms. Reinette Alecozay, Mr. John Elliot, Leslie Kempler, and MSgt.Kurt L. Stellman. We discussed pricing problems and their reaction to the ideas concerning an expert system for assisting the buyer. The price analysts present commented on the major problems faced by ATC base buyers.

e. We met with the following personnel at San Antonio Central Contracting Center (a central base procurement facility for the five military bases in the area): Ms. Yvonne Zakrzewski, Mr. Isidoro Leds, Jr., Ms. Stehanie Apple, Ms. Myrna Howell, Mr. Emil Kirbery. We discussed the problems they were having and possible ways that an expert knowledge based system might be implemented. These buyers saw little that could be gained by such a system. This pointed out the critical importance of human factors issues in implementing and operationalizing such a system. We toured their facility and briefly observed their operational environment.

2.3 Cases

Generally, the case analysis sessions were carried out by having a buyer, price analyst, or supervisory personnel "think aloud" while analyzing actual base level procurement cases. The cases were provided by the USAF and purported to be representative. The research team was not allowed direct access to the case files. The cases were current, with the oldest one being approximately two years old. The type and number of cases in the packets and a description of a typical packet are presented in Appendix III.

2.4 Protocol for Interviews

The interview sessions were organized in two parts. In the first part of the session, after explaining the purpose of the interview, the procurement person (buyer, price analyst, or supervisor) was asked to

provide demographic information such as the type and length of procurement experience, current position and grade, specialties, training and career plans. They were then asked some general questions about the procurement tasks which they performed. They were then provided with the instructions (see Appendix IV) for performing the second phase of the interview session, the case analysis phase. The interview sessions were recorded on tape and transcribed for analysis. Due to the inadequacy of the case packets, the formal experimental verbal protocols were not obtainable. However, the indepth interviews that were undertaken were considered to be adequate for obtaining the requisite information. It was not optimal but an acceptable alternative.

2.4.1 The interview protocol

The following describes the protocol followed by the interviewers in each session.

1. Each Buyer/Price Analyst will be presented with a set of cases one at a time. He will be expected to complete a case by generating a Price Negotiation Memorandum (PNM) documenting the action to be taken with respect to the case. When a case is completed, the next case will be presented.

2. Each case package consists of 5 components:

    a. Information received by the analyst from the using agency. These consist of a Request for Proposal (RFP), a government estimate, potential sources, the transmittal letter, and the statement of work (not all these items will actually be present in all cases).

    b. Information formally received from contractors. These include the actual proposals/bids, cover letters, attachments and documentation for the contractors bid (such as a price-list, manufacturer's catalogs, etc.).

    c. Information received by the analyst from the contractors, using agency, and other sources (such as Defense Contract Audit Agency (DCAA), General Services Administration (GSA), various technical specialists, etc.) in other ways (such as telephone conferences).

d. The Price Negotiation Memorandum, abstract of bids, or other documentation of the actual action taken in the real case.

e. Worksheets for use by the analyst. In this study, this will be WPAFB Form 246 (AFLC Form 1612). This form is recommended for use for writing up PNMs for contracts in the range $25,000 to $500,000.

3. The first two components of the package are given to the analyst. The third component is retained by the interviewer and the information therein is provided to the analyst if the analyst requests it while working on the case. The fourth component is for documentation purposes only. The blank PNM form is provided as a convenience (the analyst is not required to use it, but may choose to).

4. The analyst is asked to verbalize while solving the case. The interviewer's primary task is to facilitate this process, by asking questions if necessary, and providing information from component 3 of the package, if requested. The interview is taped and transcribed for later analysis.

2.4.2 General questions

The interviewers observed the buyer's/analyst's behavior and made notes to answer the following questions:

1. What information from the case packet is used or requested by the analyst?

2. What priority does the analyst assign to different pieces of information?

3. What "outside" information does the analyst request or use?

4. What assumptions does the analyst make about information that is not presented?

5. What methods and procedures does the analyst follow?

3. ANALYSIS OF MODEL (SOW 4.2.2)

In this chapter, we identify and document the rules and experience used by USAF price analysts in analyzing contractor price proposals. The objective of the interviews and briefings was to define the knowledge base required for carrying out the pricing function. The knowledge base reflects the rules and experience used by USAF personnel in analyzing contractor price proposals. Two general conclusions were reached in this regard. First, price analysis should not be viewed as an independent component of the buyer's task. Decisions made and information gathered at all stages of the process have a direct bearing on the task. The buyer's task is to establish a government objective with which to compare the proposed price. All procurement activities, not just price analysis, are directed toward establishing this objective price. Second, the process appears to be driven by the Price Negotiation Memorandum (PNM). The PNM is the formal documentation of the buyer's activities in consummating a contract at a "fair and reasonable" price. From a theoretical stand point, it is very important that the content of the knowledge base be distinguished from the procedures followed by the buyer/price analyst.

3.1 The Task Environment

This section presents the activities surveyed and discusses the specific rules and experience needed to perform price analysis.

3.1.1 Activities Surveyed

Price analysis as carried out by United States Air Force (USAF) procurement activities, is surveyed at three different procurement levels:

1. Air Force Systems Command-Central (AFSC or Systems level procurement).
2. Air Force Logistics Command-Central (AFLC or Logistics level procurement).
3. Air Force Base procurement (Base level procurement).

These activities were identified by consulting with USAF personnel as representing three diverse task environments (or levels). They are compared along the following dimensions:

1. Type of analysis generally undertaken.
2. Characteristics of procurements.
3. Type of accounting systems encountered.
4. Availability of data.
5. Expertise of personnel.
6. Utility of historical data.
7. Online computer support.
8. Type of data generally used.
9. Availability of support personnel.

As stated previously, the survey was carried out over a nine month period and consisted of attending briefings by, and conducting interviews with, supervisory and staff personnel within each activity as well as examining relevant official publications and regulations.

Figure 1 summarizes the task environment within each procurement level along the dimensions presented above. They range from base level procurement which is generally unsophisticated and under-supported to Systems level procurement which is highly sophisticated with a relatively high degree of support.

3.2 Specific rules and experience needed

In addition to the general statements presented in Figure 1, the following specific conditions and knowledge have been identified as necessary for effective procurement.

1. Prior experience with contractors (e.g., prior contract

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	Base	Logistics	Systems
Size	Large Number of Small Contracts	Mixed Intermediate	Small Number of Large Dollar Contracts
Expertise of Buyers	Low on Formal Training	Highly Qualified	Highly Qualified
	Can't Get Data	Mixed Data	Lots of Information
	No Cost Analysis	Cost Analysis Information Available	Must Do Cost Analysis
			Difficulty Using Excessive Data
TECHNICAL SUPPORT			
Personnel	Price Analysts Available for Consultation	Price Analysts Available and is Member of Team	Many Price Analysts
Computer Support	Minimal	Programs Like COPPER IMPACT, Automated Contract Writer, etc.	Cost Models Available (not robust)
Historical Databases	CIAPS, CPI, GSA, etc.	Prior Buys Often Not Helpful	

Figure 1: Dimensions of Procurement

performance, reputation).

2. Prior buys (useful at the base level, not at other levels).

3. Rules given by regulation or operating instructions:

   - checklists of tasks to be performed.

   - file and data base organization.

   - J041 routing system rules and implementation procedures.

4. Idiosyncratic rules that help them distinguish among technical terms.

5. Structure of procurement activity (this differs depending on the particular type of procurement and type of item being procured).

6. Evaluation of overhead (the perception that a high overhead is bad is simplistic and the buyer/analyst needs to be aware of this).

7. Error detection of both accounting errors and possibly deliberate errors. (Simply double-checking line items can be very beneficial).

8. Using a variety of forms (buyers found unfamiliar forms very disturbing).

9. Knowledge about the appropriate production and manufacturing processes and who the experts in the Air Force are (who to call? what information is needed?).

10. Degree of product intensive expertise (analysts at the logistics and systems level often specialize in particular types of buys).

11. Speeding up the procurement processing by initiating several subtasks simultaneously.

12. Recognizing and identifying sources and their inter-relationships (e.g., recognizing that one quote is from a vendor and another one from the manufacturer).

13. Scepticism about sole source justifications.

14. Objectivity with respect to the government estimate (degree of confidence in unrealistic or random estimates by user).

4. FEASIBILITY (SOW 4.3)

In this chapter we discuss the feasibility of developing an expert system for contract pricing. Based on information gathered in the prior phases, we define the knowledge base that can be used in developing an expert computer system.

4.1 Knowledge Base of the design

Expert computer systems can be viewed in terms of their decision making capabilities [2]. These capabilities range from an integrated intelligent system to a basic data base management system. A complete expert system would contain the necessary databases and the capabilities to perform all procurement functions of the contracting officer. A less ambitious undertaking would concentrate on performing one or more of the several components of the task, with the ultimate goal being the integration of these components into a complete system. To do this, we must determine which components of the procurement process are most amenable to performance by intelligent computer systems. An analysis of the pricing task is undertaken to this end. The following sections characterize price analysis in the Air Force, describe a system architecture for a viable system, and discuss the components of this architecture.

4.1.1 The Price Analysis Task

An expert computer system designed to support price analysis must be capable of functioning within the Air Force procurement environment. Three entities are involved in procurement: the using agency, the contractor, and the contracting officer (also called the buyer). The using agency provides a set of technical specifications and a cost estimate (or budget) of the proposed procurement. Based on the requirements set forth in the solicitation, the contractor submits a proposed price for providing the desired item or service. The contracting officer, or the designated representative, is responsible for taking the user's request, soliciting proposals, evaluating the proposals, establishing a negotiating position,

carrying out the negotiations, and consummating a contract. Throughout this process, the buyer may need to obtain in-depth technical, pricing, or legal knowledge from specialists in these areas. The following discussion presents the procurement task.

For the purpose of this research, we considered there to be six phases in the procurement process [17]:

1. Evaluate Purchase Request (or a MIPR from another arm of the Department of Defense).
2. Issue solicitation.
3. Receive proposals or bids.
4. Evaluate proposals.
5. Issue a contract.
6. Administer the contract.

In the following sections, we discuss each phase in terms of its relation to the price analysis task and the knowledge base needed to design a prototype intelligent manual.

4.1.1.1 Evaluate Purchase Request or MIPR

The following information is provided by the using agency generating the purchase request and is generally checked by the buyer:

1. Priority class of procurement.
2. Government estimate (according to the using agency).
3. Delivery schedule or performance dates (proposed by the using agency).
4. Funds authorization (provided by the funding agency).
5. User requirements (generated by the using agency experts).
6. Sole source justification (if the using agency believes that the item should be procured from a single source).

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In this phase, the buyer's primary task is to check that the requisite information has been supplied, verify it with the user or a third party, and question possible excesses. The most probable areas for excesses that can influence the final price are the priority class, a sole source procurement, the specifications, and the delivery schedule and performance requirements.

4.1.1.2 Issue Solicitations

The following represent the major components of the solicitation phase:

1. Generate formal specifications.
2. Determine a contract type.
3. Identify and verify funds authorization.
4. Identify contract line items.
5. Determine appropriate contract clauses.
6. Determine and contact possible sources.
7. Determine the kind of solicitation.

Some of this information may already have been obtained. For example, the specifications for the procurement and the line items in the contract will have been provided by the user as part of the purchase request. The buyer must then perform the other components of the above phase. For example, the buyer must choose between a fixed-price type of contract and a cost-reimbursement contract. The buyer must also identify possible sources of supply, determine the contract clauses to include and the kind of solicitation to undertake.

Contract types include:

1. Firm fixed price (FFP).
2. Fixed price incentive-firm target.
3. Fixed price incentive-successive targets.

4. Fixed price with redetermination.
5. Cost plus incentive fee.
6. Cost plus award fee.
7. Cost plus a fixed fee.
8. Cost contract.
9. Cost sharing.
10. Time and materials.
11. Labor hours.

The clauses to be included in the contract are selected from a list of general clauses organized under the following sections, as well as from subclauses appropriate to the procurement.

A. Contract Form Information.
B. Supplies/Services and Prices.
C. Description/Specification.
D. Packaging and Marking.
E. Inspection and Acceptance.
F. Deliveries or Performance.
G. Contract Administration Data.
H. Special Provisions.
I. General Provisions.
J. List of Documents, Exhibits and Other Attachments.
K. Representations, Certifications, and other Statements of Offeror.
L. Instructions and Conditions and Notices to Offerors.
M. Evaluation Factors for Award.

The user provides possible sources of supply; however, the buyer supplements this using a history of prior buys and a list of contractors maintained by the procurement office. The buyer must also choose between issuing a Request For Proposals (RFP) or an Invitation for Bids (IFB). This decision is based on the complexity and commonality of the item to be procured, the buyer's perception of the competitiveness of the situation and the local availability of suppliers. The item itself can influence the procedures followed in the subsequent phases of the procurement.

4.1.1.3 Receive Proposals or Bids

Upon receipt of the proposals/bids, the buyer's task is to extract the following information from that submitted by the contractors.

1. Total proposed price.
2. Price breakdown by line item, part number, option, etc.
3. Exceptions to technical specifications.
4. Exceptions to delivery schedules.
5. Exceptions to performance requirements.

The information provided by contractors can be used to generate the government baseline for negotiations. For example, the buyer can determine that an user-provided estimate for the unit price of a certain line-item is inappropriate and not supported by any contractor. Thus contractor provided data plays a crucial role in developing the government objective.

The buyer is also responsible for acquiring other contractor information relevant for making comparisons between contractors and with the government objective. They are:

1. History of performance on past contracts.
2. Availability of financial information on the contractor.
3. Special of contractor designation (minority-owned or small business, etc.), if any.

4. Demographic information.

5. Government contacts within the company.

6. Other government contracts with the company.

4.1.1.4 Evaluating the Contract

In the contract evaluation phase, the buyer's primary tasks are that of determining a government objective, determining the most advantageous proposal and negotiating a contract. There are four phases in this task.

1. Objective development.

2. Negotiation planning and review.

3. Negotiation.

4. Final contract.

Objective development is the process performed by the buyer in deriving a government objective for the total price of the contract or for its line items. The objective is primarily a price that the government perceives to be "fair and reasonable", but technical specifications, quantity and delivery schedules are other important factors. The activities listed below are carried out during objective development.

1. Verifying user requirements.

2. Fact finding.

3. Price Comparisons.

4. Exception comparisons.

5. Government objective comparisons.

In the previous phases, the major activities are information-gathering tasks. The objective development phase requires extensive information processing. The buyer must verify that the proposals meet the technical requirements and the delivery schedules proposed by the user. These are

routine tasks if proper procedures are followed prior to solicitation, unless there is an indication of possible problems or cost savings. When contractors take exception to solicitation requirements the buyer judges whether further investigation would be beneficial.

Fact-finding is the next phase performed by the buyer. It consists of the following activities and decisions:

1. Eliminate sources.
2. Evaluate prior buys.
3. Request and receive field reports.
4. Identify facilities to be provided by the government, if any.
5. Identify relevant outside influences on the procurement, if any.
6. Evaluate time pressures, if any.
7. Document activities performed as part of objective development.

Sources may be eliminated if proposals are unacceptable under any of the following criteria:

1. Technical reasons (whether the contractor's specifications agrees with the user's proposed specifications).
2. Legal reasons (if there are legal reasons why a contractor may not be considered).
3. Debarred (if the contractor is not eligible for government contracts).
4. Delivery schedule (if the contractor's proposed delivery schedules are unacceptable to the user).
5. Unreasonable bid (if all offers are deemed "too big").
6. Evaluation of competition (if the situation is deemed to be non-competitive).

When establishing a government objective, the buyer accesses prior

procurement history of several types.

1. Buys of the same item.
2. Buys of similar items.
3. Follow-on buys.

The identification of "similar" (and "same") buys is based on similarity (or identity) of specifications maintained in a database of prior contracts.

The buyer must request and analyze field reports from specialists such as price analysts, DCAA auditors, and technical experts. The buyer must also determine what industrial facilities are to be provided by, or are available from, the government. The effect of outside influences such as the changing prices for certain raw materials, the availability of required skilled labor, and sole source requirements must be identified and evaluated as to the extent of their impact on price. Time pressures arising from user specified delivery schedules or period of performance must be evaluated. Finally, the fact-finding process must be documented as to source, date, medium of communication and consequence.

One result of fact finding is to select one of the following procedures as appropriate for establishing a government objective:

1. Competitive Pricing.
2. Published Pricing (based on Catalog, Market or Regulated prices).
3. Secondary comparisons (such as prior quotes or formulae for developing an estimate).
4. Cost Analysis.

The result of fact-finding and the evaluation of the proposals submitted is a government objective established by the buyer. Once the government objective is established, the proposal/bids are evaluated in terms of this

objective price, the prices proposed by the other contractors, and the exceptions taken by the contractors to the solicitation specifications.

Price analysis is generally defined as the task of determining a fair and reasonable price for the buy. In the simplest situation, it may only involve comparing two numbers and choosing the smallest. It may require cost analysis — that is constructing a price based on full costs generated from engineering specifications. The information gathered during fact finding indicates the appropriate type of analysis and provides useful data for performing the analysis. Some of the information is necessarily provided by specialists who can be accessed by the price analyst. For example, field personnel can provide information as to the level of compliance with Cost Accounting Standards Board (CASB) requirements and technical specialists can provide evaluations of proposed work processes, material, and labor specifications. One system design problem is choosing which tasks to include as part of the price analysis function and which to treat as specialty areas to be called by the price analysis system when needed [10].

During the negotiation planning and review phase, the major activity is to evaluate, document, and review the government position with respect to the following issues:

1. Justification for the government position.
2. Assumptions made by the price analyst as well as those made by the contractor.
3. Strengths and weaknesses of the government position.
4. Strengths and weaknesses of the contractor's proposal.
5. Relevant range of estimates.

The following activities are undertaken as part of the negotiation process:

1. Selection of contractor(s) with whom to negotiate.
2. Resolution of identified differences in facts.
3. Resolution of identified differences in judgment.
4. Documentation of the process and the final position agreed upon.

The final contract is drawn up based upon the agreements reached during the negotiations.

4.2 Prototype Development (SOW 4.3.2)

In this section, we present the proposed architecture for an intelligent manual as well as an illustrative module of the resulting prototype system.

A complete expert system would have the following:

1. Decision making capabilities.
2. Decision support capabilities.
3. Functions to specify and support specific company or company type models.
4. User-friendly interfaces for computer-based systems.
5. Standardization within companies across contracts and across companies for the same contract.
6. Mechanisms to identify cost-estimating relationships and to catalog and retrieve Forward Pricing Agreements (FPRAs).
7. Access to available field data.

For the task evaluated, it would be very costly to implement and support this type of system. For example, such a system would rely on a large database of contracts and work breakdown information that is generally not available. We propose that the best initial approach is to implement an intelligent manual expert system and to begin to construct more "intelligent" subsystems, or "specialists", that can eventually be joined to provide a total system [10, 3, 4]. This is a realistic alternative

given current technology and the database requirements. An intelligent manual can be implemented fairly quickly, will not require a great deal of personnel retraining to implement, and does not require an extensive historical data base. The system architecture and a prototype of an intelligent manual are presented below.

4.2.1 Architecture

The architecture of the intelligent manual has four major components shown in Figure 2. They are the Task Support System, the Task Guidance System, the Task Action System, and the External Interface System.

The Task Support System supports the basic task by providing an appropriate organization for the overall task. The organization is obtained by determining how experts' perform the task is designed to support performance at that level.

The Guidance System provides explanation and guidance for performing the basic task. The structure of this component parallels the structure of the Task Support System so that a novice, on requesting help, is given the appropriate explanation and is guided to perform the appropriate activities.

The Task Action System consists of the programs and tools (such as statistical analysis programs, text editors, learning curve programs, databases, etc.) that are necessary for performing the analysis needed in the Task Support system. These programs can be invoked from the Task Support system (as well as the Guidance system); the input data required by these programs is provided via the Task Support or Guidance systems; and the generated output data is accessible from the Task Support or Guidance systems.

The External Interface System uses the results of the users interaction with the above three systems to generate appropriate output. For example, this system may generate a structured output that documents the user's

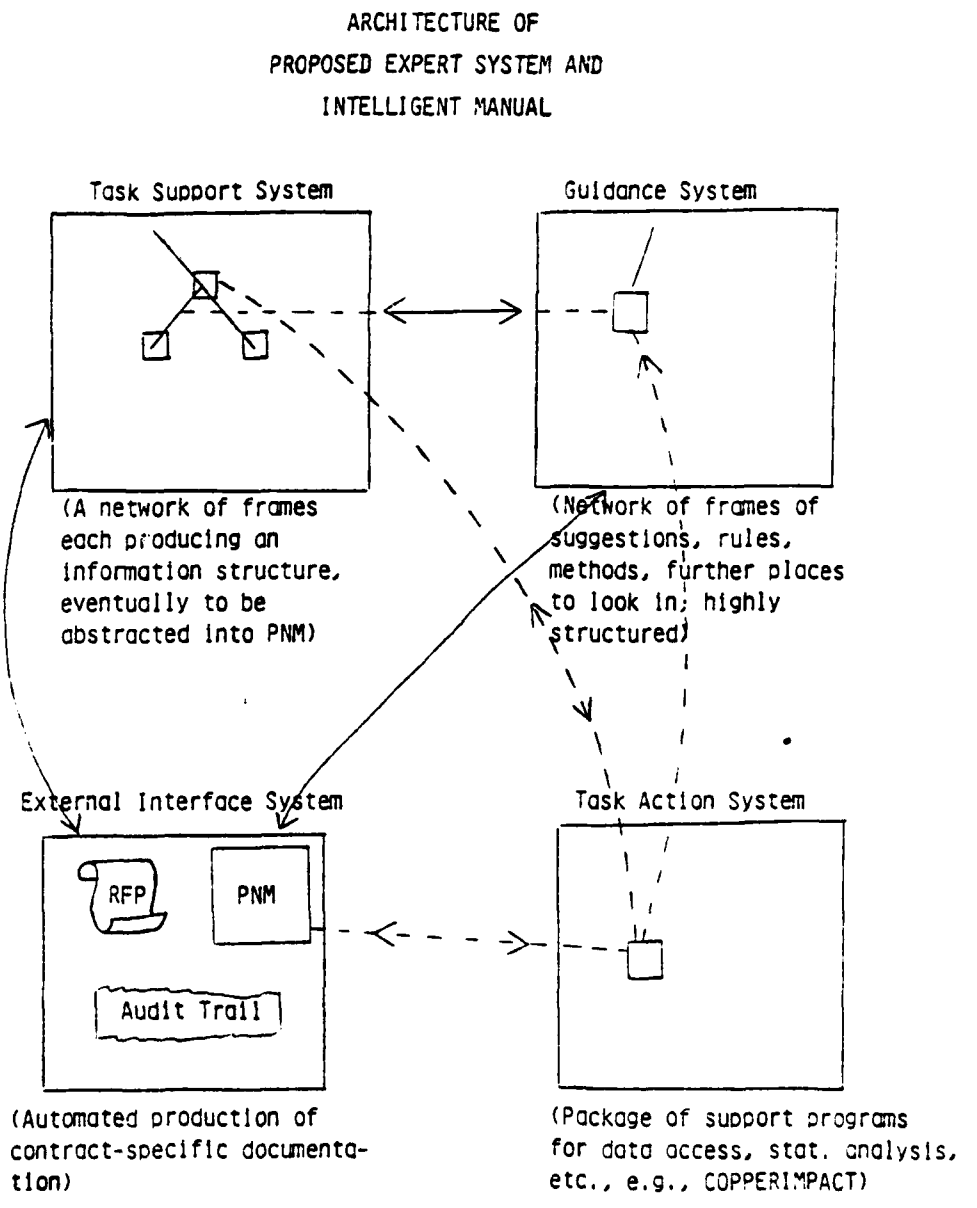

Figure 2: The Architecture of an Intelligent Manual

decision or an audit trail report that specifies the actions performed by the user and the possible reasons for these actions. Many different kinds of output are possible and all of them must be based on information gathered from the user's interaction with the other three components.

4.2.1.1 Brief Introduction to ZOG

The intelligent manual prototype is constructed on top of the ZOG information system. ZOG is a system for human-computer communication, characterized by a rapid-response, menu-selection interface to a large, network-structured, active database [14, 13]. ZOG has been applied in a number of different data base and project management situations [5, 6, 9, 12]. A ZOG-user moves from frame to frame using the computer terminal to view the contents of one frame at a time. Frames are designed to be displayed on a single screen. By convention, every frame has a one-line title at the top of the screen, a few lines of text below the title, a set of numbered (or lettered) menu items of text called "selections", and a line of ZOG commands called "global pads" at the bottom of the screen.

Frames are interconnected by the menu items. When the user selects an item (by typing its number or letter, or by touching the screen location of the item), ZOG "moves" the user to the frame "pointed to" by the selection. This new frame is displayed on the screen, replacing the frame from which the selection was made. The new frame will have the same general format; it will usually contain new information and further selections that lead to more detailed information. Basically, the frame network is a hierarchical information structure with extensive cross-referencing as well as mechanisms for moving directly from frames deep down in the hierarchy to frames much higher up. The network of frames is often termed a "ZOGnet."

Selections and frames may have associated "actions" that activate programs (or other entities) on behalf of the user. These actions are executed when the frame is displayed or when a selection is made by the user. These actions implement the connecting link between the Task Support

system and the Task Action Support system of the intelligent manual. Figure 3 shows an example ZOG frame.

```
|-------------------------------------------------------------------|
| Estimating System: Level 0 Building                     Estimate1 |
|                                                                   |
|  P. Project Name: Mining Department (Filled in by Estimator)      |
|                                                                   |
|  I. Project ID: DM-501                                            |
|                                                                   |
|  1. Location: ____(address)____                                   |
|                                                                   |
|  2. Building Type: ____                                           |
|                                                                   |
|  3. Direct Estimated Value: $xxxxx   Range: $xxxxx to $xxxxx      |
|                                                                   |
|  4. Aggregated Estimate: $xxxxx      Range: $xxxxx to $xxxxx      |
|                                                                   |
|    D. Documentation     S. Specifications       H. History        |
|    N. Supporting Notes  R. Risk Assessment                        |
|                                                                   |
|                                                                   |
|edit help back display  root next prev last new old  print fill chk|
|-------------------------------------------------------------------|
```

Figure 3: An Example ZOG Frame Estimate1

The ZOG system is primarily used to organize the Task Support System and the Task Guidance System. Functions provided by the Task Action System and the External Interface System can be controlled from ZOG via the selection mechanism.

4.2.2 Structure of the Task Support System

The Task Support System is organized as a hierarchy. Every node in the hierarchy is implemented as a frame in ZOG. The hierarchy is defined by the hierarchical organization of the tasks that the buyer must perform during procurement. This organization has been discussed earlier and is shown briefly in Figure 4.

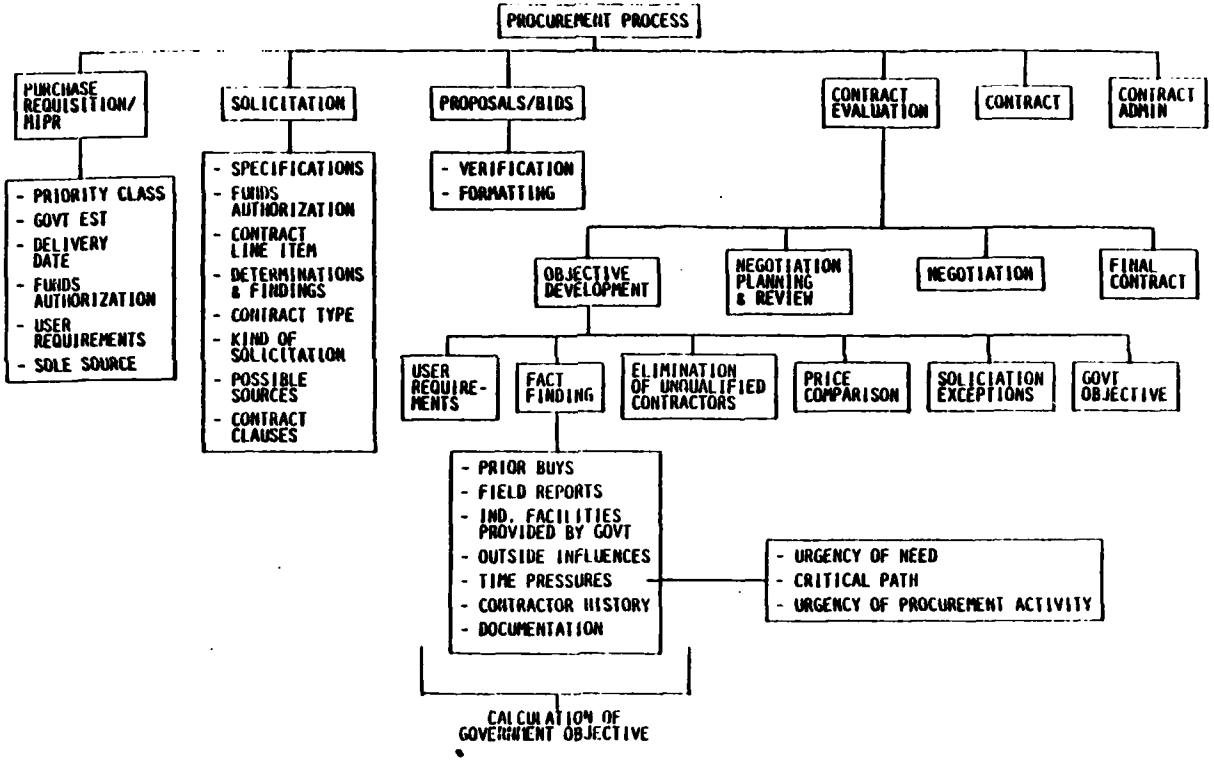

Figure 4: The Procurement Task

4.2.2.1 Implementation of the Prototype

There are three basic types of frames in the ZOG prototype. They are:

1. Node frames that maintain information about some task or sub-task of procurement.
2. Decision/Selection frames that maintain information about decisions made during procurement.
3. Database frames that contain pricing and other information.

Node frames allow the user to focus on a subtask, as well as provide context to organize the task. The Decision/Selection frames provide the structure for the user to make decisions by appropriate selections at the frame. They contain local pads that enable the user to make the selections interactively. They also provide the user information on making the decision as well as the ability to postpone making a final decision or to make partial decisions. The Database frames provide the user access to data on contracts. They contain mechanisms that allow the user to fill in and edit data as well. The typical database frame is organized as a two-dimensional table, though other structures (lists, etc.) are also possible.

Every frame has an associated "Help" local pad. In the case of Node frames, these connect to parallel frames of the Task Guidance System. For Decision/Selection frames, they connect to frames in the Task Guidance System that discuss the decisions to be made and provide help in making the decisions. For Database frames, they lead to frames that explain the functions available as well as explain the data being displayed.

Figure 5 shows a Node frame. The options in the node frame lays out the subtasks that are needed to perform the task identified by the frame. The text of the frame is (or should be) minimal, if any. In the frame shown in Figure 5, for example, the text simply classifies all the sub-tasks into two groups.

Figure 6 shows a Decision/Selection frame. This frame allows the user

System for Price Analysis

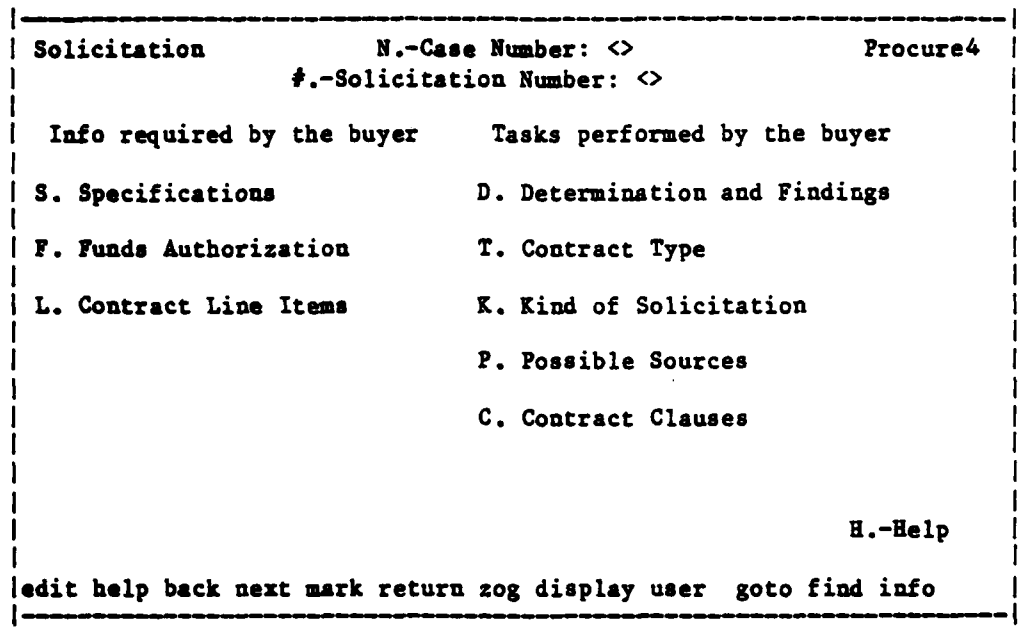

Figure 5: A Node frame — The Solicitation task

has to determine what items being procured are likely to be affected by time pressures. The items and the contract option that they occur under are the rows and columns of the matrix. The user can select from the set of local pads. For example, if the user decides that Item 1 is not affected by time pressures at all, he selects the E. Row not affected local pad and then types `1' to specify the row.

Figure 7 shows a Database frame.

This frame shows the total price proposals by different contractors on the main and optional parts of the solicitation. It is organized as a matrix. There may be more options than can be shown; similarly, there may be more than the eight proposals shown. In this case, the matrix is extended over many frames and every frame only displays a "window" into the matrix. There are ZOG local pads (F. First, L. Last, >. More, <. Prev, and others) that provide mechanisms for moving to different windows (i.e.,

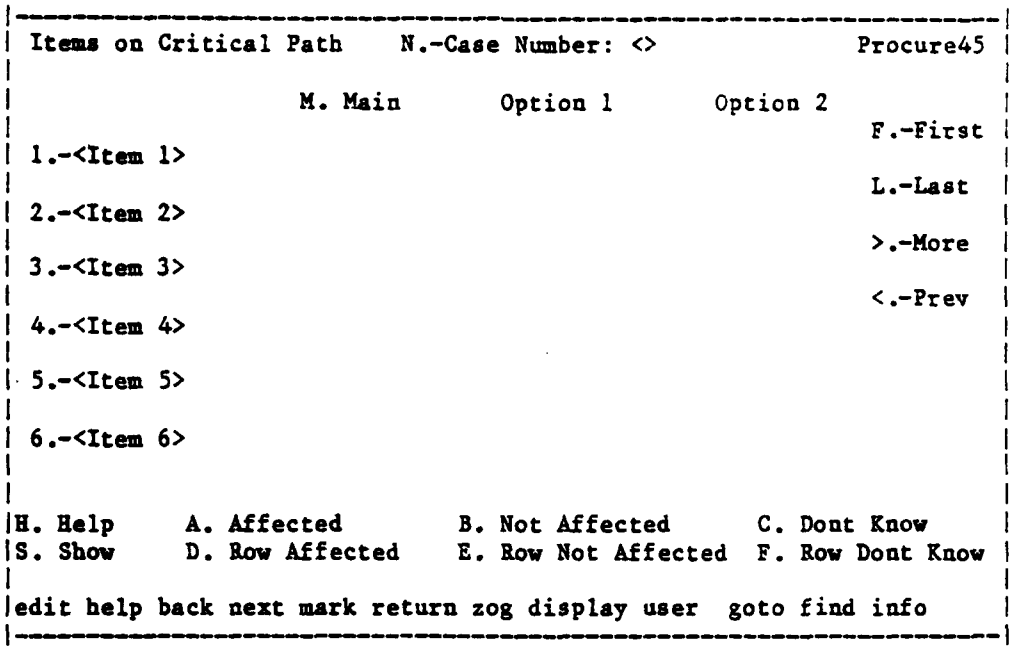

Figure 6: A Decision/Selection frame — Selecting Contract Type

frames). There are also local pads that allow entry of new information and deletion or modification of old information, so that the same frame can be used to create the matrix initially.

A database frame is really a point of entry for the user into a database. For particular databases, there may be better mechanisms for access, use, and modification of the database than the ZOG frame structure. As explained earlier (using the Task Action System), ZOG can make system improvements available to the user. So a mismatch between ZOG structure and a database structure should not be an insuperable barrier.

4.2.3 Structure of the Task Guidance System

The ZOG-based pricing guide is intended to guide the user through a series of questions that must be raised in procurement situations. If the user cannot answer a particular question, the system breaks the issue down

System for Price Analysis

```
|-------------------------------------------------------------|
|              N.-Case Number: <>                  Procure28  |
| Total Price Comparisons Across Contractors and Options      |
|                  M.-Main   A.-Option 1   B.-Option 2        |
|  1.-<Contractor-A>                                F.-First  |
|  2.-<Co-B>                                        L.-Last   |
|  3.-<Co-C>                                        >.-More   |
|  4.-<Co-D>                                        <.-Prev   |
|  5.-<Co-E>                                                  |
|  6.-<Co-F>                                        I.-Insert |
|  7.-<Co-G>                                        R.-Remove |
|  8.-<Co-H>                                                  |
|                                                             |
|edit help back next mark return zog display user  goto find info|
|-------------------------------------------------------------|
```

Figure 7: A Database frame — Proposal Comparisons

into more basic issues. For example, the question "Is this a competitive situation?" can be broken down into such questions as:

1. Are there two or more independent contracts?
2. Do each of the contractors satisfy the solicitation criteria?
3. Is the procurement object generally available to the public?

In the first level of the system, the user will be guided to answering questions by breaking them down into simpler questions. This procedure will not necessarily aid a complete novice. The novice (and experts, too) may find examples and definitions of terms useful. The second level of the system provides this kind of support. Examples and elaborations of

questions and the kinds of answers expected by the system are provided to the user. This may still not suffice. At the third level (currently the lowest level that has been defined), the user will be directed to a "learning net". This is a piece of the ZOGnet that presents the information needed by the user in a textbook/tutorial style. In this presentation, we only present the design of the first level ZOGnet (the guidance system).

Figure 8 displays the complete structure of the pricing guide. We have chosen a somewhat abbreviated notation to indicate some of the issues, questions, and sub-questions that must be raised by the user.

In the first level, every frame contains four components: an Information component that provides the user some information; an Action component that instructs the user to do something; a Decision component that poses a question to the user that must be answered with reference to the contract(s); and, an Option component that provides the user with a set of possible answers to the question.

The Decision and Option components determine the structure of the network. Most questions will have "Yes/No" answers, though others may have slightly more complex answers. In any case, the questions are formulated so that they can be answered from a small menu. Figure 9 shows a question that the buyer is confronted with by the system: "Is each offer priced and responsive to the requirements of the solicitation"? The answers can be Yes or No. Such a frame is called a Decision-Option frame — there are no Actions. The information presented in the frame directly explains the question. If the answer is "yes" or "no" (selects menu items 1 or 2, respectively), the buyer will be taken to a Review frame (see Figure 10 for an example). This gives the buyer the opportunity to review the decision (by reading the information presented) before taking an action. In the case that the buyer is not sure, the S. SPECIFY local pad will lead to a sequence of Decision-Option frames that elaborate on the question. These will ultimately terminate in some other Review frame (or frames). If the

System for Price Analysis

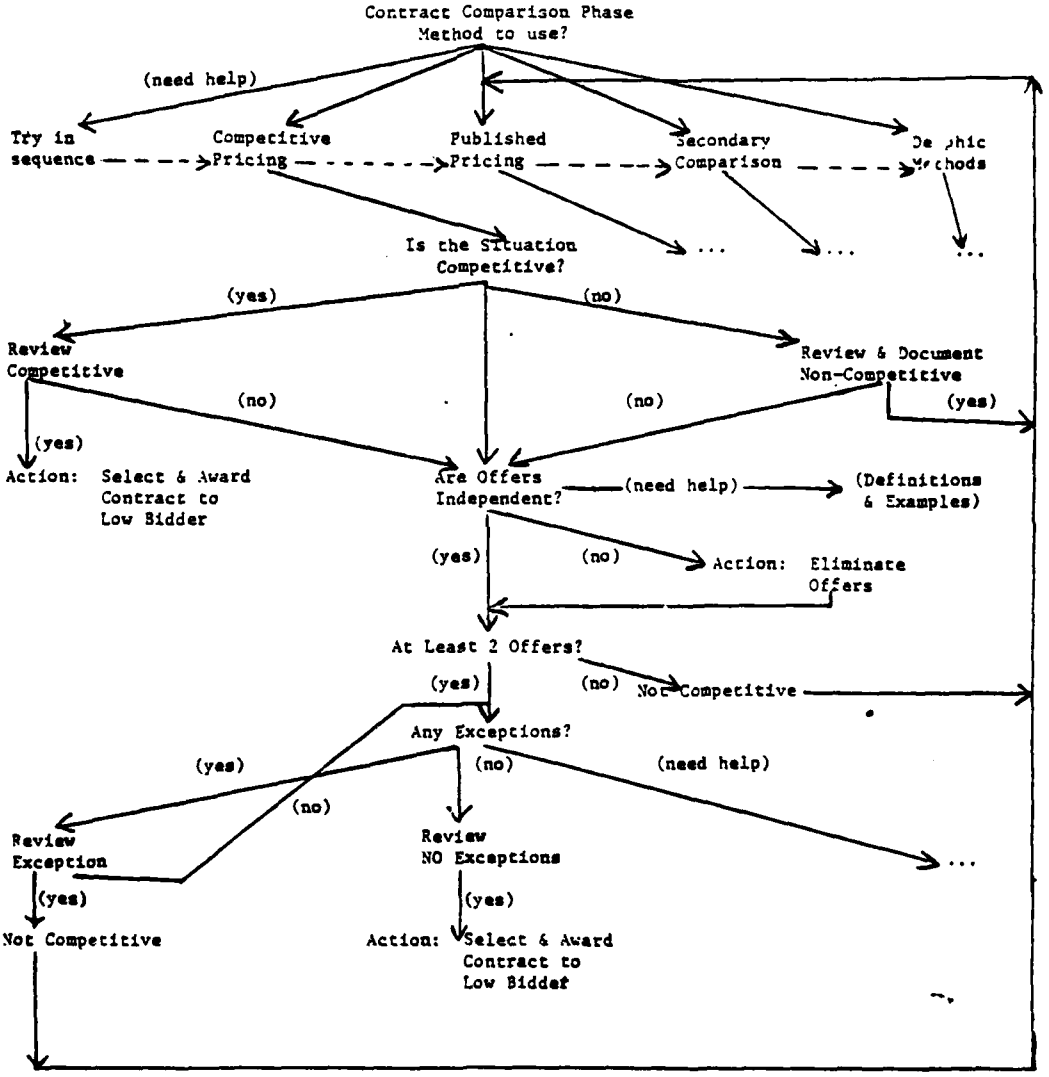

Figure 8: Structure of the Price Analysis Guide

buyer is totally confused as a result of unfamiliarity with the domain, the E. EXAMPLE local pad will lead to an example, while the L. LEARN local pad will lead the buyer to the learning ZOGnet.

A Review frame typically presents the buyer with a summary of the reasons for making the decision and requests confirmation. The buyer then has the opportunity to retract. In the example shown (Figure 10), the buyer may realize that two proposals do not come from independent contractors (this requirement may have been ignored by mistake earlier). The buyer can select 1. Continue to go on to perform the action associated with the positive decision or select 2. Document to perform the action associated with the negative decision, or select S. SPECIFY to postpone making a definite decision.

Once a decision has been made and reviewed, the guidance system also provides mechanisms for implementing the action to be taken using Action frames. An example is shown in Figure 11. The frame text explains the action(s) and instructs the buyer in performing the action. Selecting 1. Continue allows the buyer to perform the action while 2. Return allows the buyer to postpone the action (and possibly retract the decision to perform it). If the buyer is uncertain of how to perform it, the S. SPECIFY local pad will provide further detail and explanation.

The above example of a ZOG system is not a problem-solving or a problem-analysis system. It shows the underlying model of the domain that would help a user perform the task of price analyst without necessarily having the expertise or the training. However, it also performs another important function. It identifies the questions that an intelligent system must answer and is useful in identifying the information necessary to answer these questions. Some of this information must be obtained from the source documentation such as a purchase requisition; some of this information must be obtained from knowledge of the regional and national economy; other information is unique to the contractor or contractors. All of this knowledge must be accessible to the intelligent manual in an appropriate

```
Pricing Specifications                                    Pat27

Each solicitation has specific requirements about the type of
contract that is acceptable (e.g., firm fixed price, cost-plus,
etc.) and a requirement as to how much pricing data must be
given.  You must determine if each offer is priced and
responsive to these requirements.

 IS EACH OFFER PRICED AND RESPONSIVE TO THE REQUIREMENTS OF THE
                        SOLICITATION?

      1.  Yes

      2.  No

S.  SPECIFY          E.  EXAMPLE          L.  LEARN

edit help back next mark return zog display user goto find info
```

Figure 9: A Decision-Option frame

representation.

4.2.4 Task Action and External Interface systems

The Task Action System and the External Interface System are necessary components of the intelligent manual architecture. However, the design of these systems is largely determined by task considerations. For example, the system must generate solicitations to send to contractors. The buyer's decisions about the content and form of the solicitation are determined by the Task Support system. The External Interface system can generate a complete solicitation and send it off automatically. The design of the solicitation at this level (legal document, on paper, etc.) is independent of the buyer's problem-solving or information-gathering activity. Similarly, the PNM can be generated automatically from the documented decisions of the buyer.

The Task Action system provides the buyer with a variety of utilities.

```
Review Competitive                                              Pat33

By claiming that a competitive situation exists, you are claiming
 that:

 (1) At least 2 responsible offerors responded to the solicitation
      and passed the Contract Selection Phase.
 (2) The offerors independently contended for the contract.



                IS THE SITUATION COMPETITIVE?


  1.  Continue

  2.  Document (not a competitive situation)



    S. SPECIFY              E. EXAMPLE              L. LEARN

edit help back next mark return zog display user goto find info
```

Figure 10: A Review frame

For example, the Task Action system may contain programs for plotting learning curves. The data for the programs may be obtained from the buyer via ZOG or may be available as online data, or may already be a part of ZOG in Database frames. The output of the program should be accessible to the buyer via ZOG. The Task Action system therefore consists of three kinds of programs:

1. Programs that know how to interface with the ZOG system and the ZOGnet structure.
2. Programs that ZOG can control (via terminal-mode commands).
3. Programs that ZOG can communicate with and vice-versa.

For example, COPPER IMPACT programs can be incorporated into the system. Since these programs have not been designed with ZOG in mind, they cannot be used in either the first or second categories. However, the Task

```
Offer Elimination                                          Pat28

Those offers that fail to meet the technical specifications
of the solicitation must either be revised and resubmitted or
eliminated from consideration.


     ELIMINATE THOSE OFFERS THAT DO NOT MEET THE TECHNICAL
   SPECIFICATIONS OF THE SOLICITATION AND CANNOT BE REVISED
                    AND RESUBMITTED


        1.  Continue

        2.  Return


S.  SPECIFY              E.  EXAMPLE              L.  LEARN

edit help back next mark return zog display user goto find info
```

Figure 11: An ACTION frame

Support System and Task Guidance Systems can be designed with knowledge of COPPER IMPACT programs and can control it via a simulated terminal interface. The output of these programs can be analyzed and incorporated into the database and accessed via a ZOG interface to the database. Over a period of time, these programs can be modified so that they communicate effectively with the support and guidance systems.

Once the support and guidance systems are established, programs can be written that understand the ZOGnet structure and can get their input data from the net and incorporate their output directly into the net. These programs would be closely integrated into the intelligent manual.

4.3 Conclusion

The major benefits of intelligent manual expert systems for procurement decision making in the Air Force are:

1. A reduction of the skill level necessary to perform routine procurement tasks.

2. Automatic documentation of the steps taken in performing the task.

The types of assistance that could be provided within the intelligent manual alternative are:

1. Guide price analysis by providing question sequences and elaborating and explaining issues surrounding the questions.

2. Provide on-line general and specific indices.

3. Make available data bases of historical contract data.

4. Make available general models of contractor types.

5. Specify general parameters for analysis.

6. Provide cost modeling of the contractor's estimation systems.

7. Provide guidance in establishing parametric and predetermined rates.

8. Provide access to previously established parametric and predetermined rates.

The greatest benefit of implementing an intelligent manual would be in environments where little expertise or support is available (Base level procurement is clearly such an environment). Two major objectives could be achieved. First, the user would be provided with price analysis assistance which is not currently available. Instead of having to rely on expert support that is not always available, the user will be able to perform the task directly. The system will provide structure as well as data required for the task. The skill level required to do price analysis would be reduced. Second, the audit and evaluation processes will be expedited. The system is designed to take the responses provided by the user and construct the required verification documentation as well as to provide an audit trail of the steps taken. Also, necessary indices as well as pertinent procedures and regulations would be readily accessible.

Analytical tools and spread sheet capabilities would be made viable.

In the long-term, problem-solving expert systems can be constructed to perform more of the pricing task and to provide more aid to other levels of the price analysis function. How rapidly this takes place will depend on the effective implementation of the intelligent manual system and the requisite knowledge bases, and the effectiveness of the procedures for maintaining and updating the system.

5. FUTURE RESEARCH (SOW 4.3.3)

In this chapter, three future research areas related to the proposed expert system are identified. They are:

1. Human interface issues and related implementation problems.
2. System extensions to include cost analysis at other procurement levels.
3. Prototype application and expansion.

Each is discussed in further detail, and the issues and research required to deal with them identified.

5.1 Human Interface Issues

The original statement of work paid scant attention to user interface issues. However, it has become apparent from our investigation that these issues were one of the major reasons why prior Air Force systems for supporting price/cost analysis have been ineffective. There are two sets of tasks to be accomplished.

1. User interface problems in base level pricing need to be evaluated and identified. There are two possible orientations for this kind of study. One, the problems with the proposed intelligent manual can be studied. Two, the problems that currently exist with other AF programs (or some subset of these) can be studied.
2. The intelligent manual needs a good user interface. This must be designed to respond to the human interface problems identified earlier.

5.1.1 Issues in Human-Computer Interface design

A number of different classifications of human-computer issues have been proposed in the literature [16, 15] . Many of these criteria take the form of "rules-of-thumb" — they define characteristics of good systems and are classified in some natural groups [11, 7, 8]. For example, the top level

of the list in Gebhardt and Stellmacher is:

1. Simplicity.
2. Clarity.
3. Uniqueness.
4. Comfortable Language.
5. Other comfort.
6. Evidence and Re-usability.
7. Stability.
8. Data Security.

For each of these items, there are simple design criteria that, if followed, should result in a good interface. For our purposes, such a list of rules is not very useful as it does not identify the principles behind the items in the list and therefore the application of the rules in different systems need not result in uniform design.

The recent book by Card, Moran, and Newell [1] classifies human-computer interface design issues into three sets of structural variables corresponding to the three structural components of an interface (the user, the task, and the computer system), and four sets of performance variables characterizing the behavior of the human-computer system. These issues are identified in Figures 12 and 13.

We may also view the problem (for price analysis) as one of designing an interface to an information system. If so, a list like the one defined by Ramakrishna [12] would be appropriate. This list is an attempt to characterize the capabilities that the system must possess (and can therefore be subsumed within the System Variables component of the list in Figure 12).

1. Information Structuring Issues: What facilities does the system provide for structuring information?

System for Price Analysis

Task Variables	User Variables	Computer Variables
Task Domain	Intellectual Abilities	Dialogue Style
	General Intelligence	
	Technical Ability	
Task Model	Cognitive Style	Command Syntax
	Risk Preference	
	Curiosity	
	Persistence	
	Experience	Naming Conventions
	On System	
	Frequence of Use	
	Knowledge	Display Layout
	Method Knowledge	
	Conceptual Knowledge	
	Task Expertise	
	Perceptual-Motor Skill	Input Devices
	Typing Rate	
	Manual Skill	
		Response Time

Figure 12: Human-Computer Interface design: Structural variables

Basic Measures	Subjective Measures	Extreme conditions	Memory
Functionality	Acceptability	Fatigue	WM Load
Learning	Enjoyableness	Stress	LTM Recall
Time			
Error			
Quality			
Robustness			

Figure 13: Human-Computer Interface design: Performance variables

2. Information Distribution: What mechanisms support the location, referencing, and distribution of information?

3. Level of Integration of the User Interface: The extent to which the user interface is flexible, consistent, and uniform.

4. Development and Evolution: Does the system provide a strategy for the formal and informal development of the system under user guidance?

5. External representation Issues: Does the system provide a

mechanism for automated and other input/output of information?

These issues are slightly different from those described earlier; however, they may be relevant to the discussion in the context of price analysis.

The term "user-friendly" captures the essence of the concept that systems should not intimidate users with their complexity or with their idiosyncratic organization of a task that the user believes can be performed in other ways. If there is a comfortable alternative to the computer system, the user will prefer that alternative rather than face an unfriendly system. The above layout of interface design issues essentially categorizes all that is now known about user-friendly design.

5.2 Extension to Cost Analysis

The intelligent manual approach could be expanded to include cost analysis. The cost analysis task is more structured and thus might be more amenable to a deductive-style of expert system design. This extension will test the system's capabilities in the Task Action component and extend beyond the current spreadsheet capabilities of COPPERIMPACT.

Including cost analysis within the capabilities of the system projects its use by central procurement activities. This procurement environment is significantly different from the base-level procurement environment. The following major tasks would need to be accomplished:

1. Collecting materials on how various subtasks of central procurement are to be performed.
2. Identifying the different kinds of cost analysis and how they might be done by an expert system.
3. Identifying different tasks/sub-tasks in the accounting/auditing domains and determining the ways to accomplish them.
4. Determining what kinds of expert systems (or human interfaces) are appropriate for the tasks.

A prototype expert system would have to be designed capable of

performing some selected set of cost analysis tasks. This system could be integrated into the current prototype intelligent manual. In implementing the selected subtasks, studies of price analysts performing those subtasks (using protocol analysis) would be undertaken. Thus the implementation task will require two stages: data gathering and system design/implementation. Cost analysis cases are generally better "cases" than price analysis cases; thus, there is a higher likelihood that protocol analysis could be successfully carried out. Two subtasks of cost analysis suggest themselves as ideal for implementation:

1. Developing a profit objective, and
2. Determining the applicability of Cost Accounting Standard (CAS) 414 (Facilities and Cost of Money).

5.3 Extension and completion of current prototype

The current prototype intelligent manual only covers one aspect or type (Competitive Pricing) of base-level price analysis. There are two other aspects of price analysis that the system discusses, but does not currently cover. They are Published Prices and Secondary Comparisons. Also, though the intelligent manual attempts to establish the procurement context within which the buyer functions and provides some support for procurement activities, the system's does not fully support these capabilities.

Attempting to establish system use in a realistic setting would raise human interface issues identified earlier as well as issues concerning the efficacy of the knowledge base and databases associated with the system. Other issues such as the availability of hardware, the nature of the hardware, the needs for networking between buyers and price analysts, the need for online information as well as help would all have to be addressed.

6. LIMITATIONS OF PROPOSED SYSTEM (SOW 4.3.3)

This chapter discusses the limitations of the current prototype intelligent manual.

Price Analysis is only a small component of the overall procurement activity of the buyer. Other problem-solving, information gathering, and decision making activities must be carried out. Most of these other activities are less amable to "expert systems" technology applications. However, the user can be supported to varying degrees while performing them. For example, a system for training negotiators, or a system that interviews the user of an item proposed for purchase to determine the technical specifications (or aids the buyer in the interview) may be as useful as a price analysis system. The ZOG-based intelligent manual approach would be a first step in the design of such systems.

The primary limitations of the proposed prototype system relate to the restricted focus of the study. The task support and guidance systems that interact most heavily with the buyer contain no reasoning capability. They provide the user with structure and assistance for making decisions, but do not draw inferences based on prior decisions. The human-machine interface is not as well developed as desirable. As discussed earlier, this may be a major impediment to successful implementation of the system.

The system is designed for base-level procurement. Modifications needed to apply the system in other procurement environments must be identified and incorporated into the system. Including cost analysis capabilities as part of the system is an example of such an extension. The prototype also is directed primarily at buys of between $10,000 and $500,000. These differ significantly from the excluded buys.

The system has not been tested with respect to actual expert behavior. Two issues are involved here. First, this kind of testing requires that the prototype be implemented and subjected to the tests of the work place. The

7. ALTERNATIVE SOLUTIONS (SOW 4.3.4)

In this chapter we identify several alternative solutions that can also enhance the procurement process. These include alternative expert systems for computer-aided cost/price analysis.

7.1 Alternative Structures for the Problem

Two expert system alternatives are to construct a simple deductive system or to construct a data-rich knowledge manipulation system. Both alternatives possess a higher level of "intelligence" than does the proposed expert manual.

7.1.1 Simple Deductive Systems

A system capable of making simple deductions on its own requires some reasoning capabilities. One way of designing such a system is to construct a subsystem containing a control structure, one having a capability for making historical deductions given specified relationships, and specialists that can be called when specific expertise is needed. In the case of price analysis, the specialists would include accounting, management, auditing, and overhead allocations. The user would be required to provide the system with input data and also respond to requirements which could not be handled by the system. These circumstances would most likely be encountered where the buyer either interfaces with other specialists, needs information not contained in the system's data base, or where unstructured reasoning is required to solve the problem. Note that this alternative assumes that these other specialists will be available online — either live or in the form of an expert computer system.

The major impediment of this alternative is that the data bases and other support requirements are not available. However, current technology appears to be adequate to construct such a system within the procurement environment given the developmental resources.

7.1.2 Data-Rich Knowledge Manipulation Systems

A data rich system would be the ultimate in intelligent systems for contract price analysis. It would have the capability to read the contractor's proposal and based on the historical and analytic data in the system, analyze the contract and formulate a government position. This requires that the system have access to the technical specifications of the buyer, a history of the activity in purchasing related items, a history of the contractor's performance on other contracts, a history of similar contractors and similar buys as well as the logical reasoning capabilities required to analyze the the current contract in light of these considerations.

Implementing such a system would require very good analytical tools as well as data-base capabilities currently not available (and not expected to be available for a considerable period of time). This is the most viable alternative in the very long-term (25 years or more). Realistically, such a system is unlikely to develop in a systematic way but would probably evolve in some manner from existing piece-meal systems.

7.1.3 COPPER IMPACT Based System

An expert system using COPPER IMPACT as its basis is not a viable alternative. COPPER IMPACT does not possess the requisite capabilities for such a task. It is primarily a set of programs with statistical and spread-sheet capabilities. As explained earlier, it would be useful as a component of the Task Action system in the intelligent manual, or as an auxiliary system to another expert system. Likewise, superimposing an expert system tutor on top of COPPER IMPACT would be of little benefit given the limitations of COPPER IMPACT system and its documentation. One of the major faults with COPPER IMPACT has been its user-unfriendliness — superimposing an expert system on top of this would not change this primary problem.

Other systems currently used by procurement personnel (CIAPS, etc.)

provide data bases that would be useful for any expert system. However, none of these were designed to provide a basis for constructing expert systems. They occasionally share COPPER IMPACT's unfriendliness; in general, they all tend towards inflexibility in command languages.

7.2 Non-expert Systems

Non-expert systems which provide online assistance would be helpful to procurement personnel. Attempts are currently being undertaken in several areas such as online contract writing, procurement history maintenance, electronic mail, and others. The human factors implications of these implementations need to be evaluated and improved. If designed carefully, these systems might provide the basis for building future expert systems within the procurement environment.

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II. LIST OF PERSONNEL INTERVIEWED

Bob Hill, AFLC Headquarters, WPAFB.

Rollie McReynolds, AFLC Headquarters, WPAFB.

Viola Williams, Supervisor, 2750th Air Wing, WPAFB.

Marty Spaare, Supervisor, 2750th Air Wing, WPAFB.

Bill Bower, Price Analyst, AFLC, WPAFB.

Charles Warren, Price Analyst, AFLC, WPAFB.

Roy Bondurant, CDMS, AFLC, WPAFB.

Barbara Walls, Chief, System Management Section, 2750th Air Wing, WPAFB.

Nancye Donaldson, Buyer, 2750th Air Wing, WPAFB.

Anita Maldonado, GS-11, Contract Negotiator, PMWAA/56891, Aircraft Branch, Weapon Systems & Major Equipment Div (PMW).

Billy Sullivan, GS-12, Contract Negotiator, PMZMM/58461, Instrument Branch, Commodities Div (PMZ).

Patricia Larzelere, GS-9, Contract Negotiator, PMWPD/57111, Propulsion Branch.

Rita Brown, Contract Negotiator, PMZAM/56603, Support Equipment Branch.

Earl Booth, GS-12, Contract Price Analyst, Pricing Division/PMF/57121.

Leroy Hassler, GS-12, Contract Price Analyst, PMF/57121.

The Design of an Expert

Margaret Cames, Automated Contract Writing, Kelly AFB.

Reinette Alocozay, Price Analyst, HQATC/LGCA.

John Elliot, Price Analyst, HQATC/LGCA.

Leslie Kempler, Director, HQATC/LGCA.

Kurt L. Stellman, MSgt., HQATC/LGCA.

Yvonne Zakrzewski, Buyer, LGCVC-1(construction).

Isidoro Leds, Jr., Buyer, LGCVS.

Stephanie Apple, Buyer, LGCVP.

Myrna Howell, Buyer, LGCJF(Supply).

Emil Kirbery, Buyer, LGCSK.

III. LIST OF THE CASE TYPES REQUESTED AND THE CASE TYPES RECEIVED.

Based on our investigations, we classified procurement situations into a small set of categories and requested a small number of cases for a selected set of categories. The classification is presented below with the number of cases requested in each category and the number received in that category in parentheses. Our study was focused on base-level, intermediate size purchases, and so we did not desire any cases from the very low end or the high end of the size spectrum. We determined the numbers of cases we wanted to receive by roughly estimating their relative frequency (based on discussions) and setting a maximum limit on the number of cases we expected to show buyers and price analysts. We presume that the numbers we actually received represent the actual frequency of these cases.

It will be apparent that we received many cases in categories that were not appropriate for this study, and did not receive sufficient cases in certain categories. Initially, we attempted to ensure that we had a well-distributed set of complete cases; however, the wait for complete cases in appropriate categories to be accumulated was seriously jeopardizing the time schedule for the project and we decided to go ahead with what we had. (The first number in the parenthesis indicates the number of cases requested the second indicates the number received.)

I. Small Purchases

A. 0 to $1000: No price justification required (0, 0).

B. $1000 to $25,000: Price Analysis only; Buyer cannot ask for cost data (4, 12).

II. Intermediate Purchases ($25,000 to $500,000)

A. Price Analysis

1. Competitive

a. Actual Competition (2, 2)

b. "Based on" Competition (2, 0)

c. Competitive Environment (2, 0)

2. Catalog Prices

a. Actual Catalog Price (2, 2)

b. Based on Actual Catalog Price (2, 0)

3. Comparison to Prior Purchases (4, 4)

4. Government Estimate

a. Detailed Estimate (2, 1)

b. Lump-Sum Estimate (1, 0)

5. GSA Schedules

a. Mandatory (1, 1)

b. Non-Mandatory (2, 2)

6. Value Analysis (1, 0)

B. Cost Analysis

1. General Cases: Buyer must decide if DD Form 633 is to be used (1, 4).

2. Special Cases

a. Construction (0, 2)

b. 8A Set asides (0, 0)

c. Service Contract-Act Price Adjustments (0, 1)

d. Packaging Costs (1, 0)

C. Exercise of Options (DAR 1-1505) (0, 0)

III. <u>Large Purchases</u> (over $500,000)

A. Price Analysis: Contractor uses DD form 633-7 (1, 3).

B. Cost Analysis

1. General Case (0, 0)

2. Special Cases

1. Construction Mods (0, 4)

2. 8A Set Asides (0, 0)

3. Service Contract-Act Price Adjustments (0, 0)

4. Packaging Costs (0, 0)

During an interview with an analyst, the interviewers used the following brief description of a case packet as a reference. We provide this as a description of a typical case in lieu of a sample case packet.

CASE NO. 6 BASE LEVEL PRICING

Type: GSA non-mandatory schedule

Contract No.: F33601-83-F3563

Item: Signal generator

Contents:

1. Order for supplies or services (DD1155)

2. Request for proposal

3. Requisition (DD1348-6)

4. Specifications—appear to be pages out of the offeror's catalog

5. Computer printout of something that looks like an abstract of bids — appears that another contractor was contacted but was not able to give a quote because they do not carry this model. Seems to serve as a PNM.

Remarks:

1. No PNM

2. Only one bid but buyer attempted to secure another bid from one other supplier. The other supplier could not meet specifications and therefore could not submit a bid.

3. Appears that the contract number changed in process. No mention of why this might have happened. Possibly, the first attempt to secure a proposal was not satisfactory (for instance, all the bids may have been too big, or no bids were received) and the solicitation had to be redone.

4. The price from the offeror's catalog appears to be $7900.00, however, the contract price is $7680. What is the reason for this difference? This is not mentioned in the material provided. Most probably, the company gives the government a 4% discount if the buyer asks for it.

IV. WRITTEN INSTRUCTIONS FOR INTERVIEWS

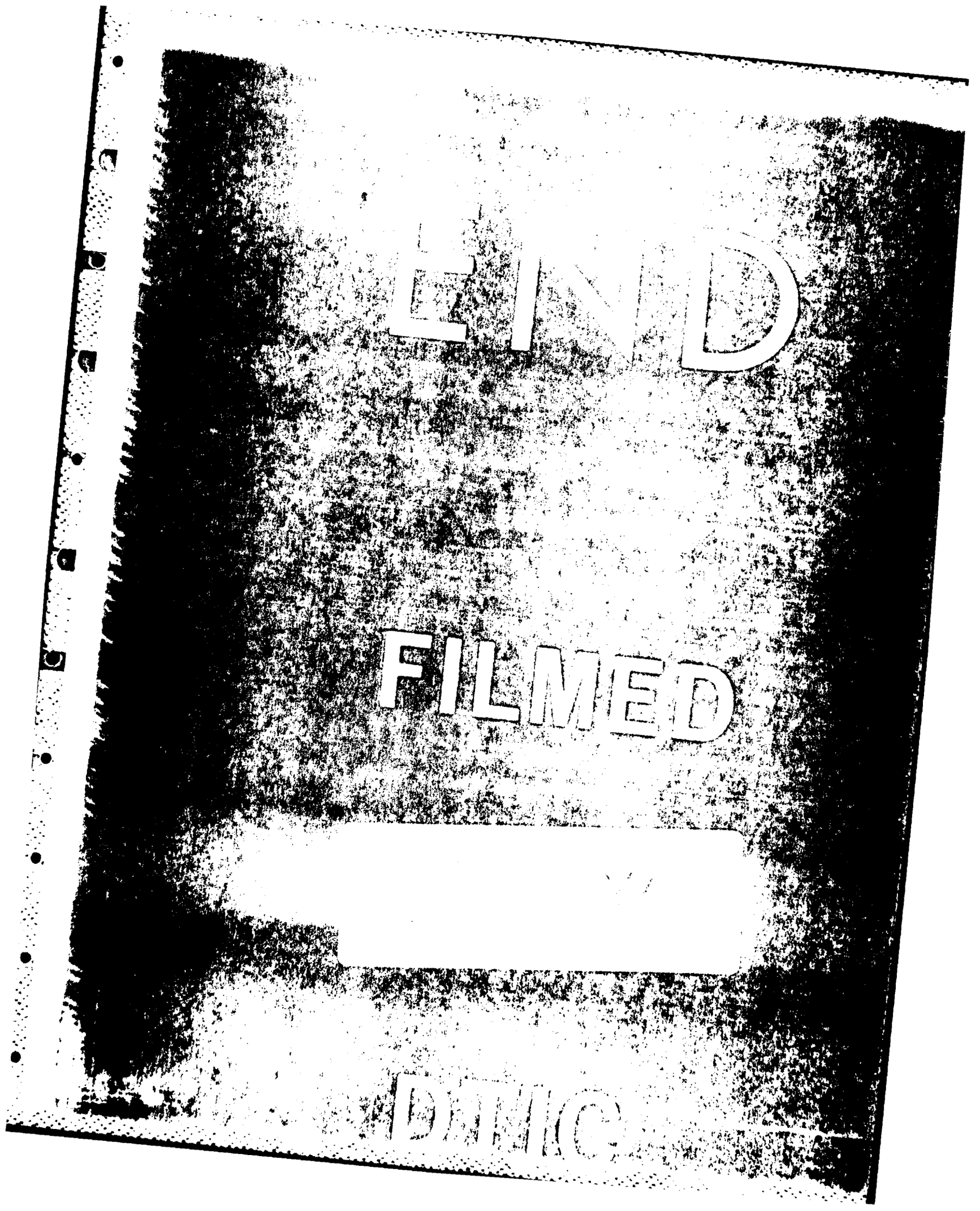
The objective of this study is to understand your methods for analyzing proposals to determine a fair and reasonable price and for selecting a proposal.

We will do this by showing you a set of cases. In each case, we will give you: the Purchase Requests and other information relevant to the case; the bids/proposals from contractors and documentation relevant to these bids. As you go through these cases, please talk aloud about the steps you are performing, the assumptions you are making, or the procedures you are following. If you need any additional information, you can ask us, and if we have it, we will give it to you.

Some of the case packets that we will give you are incomplete; this is NOT a test of your ability to detect incomplete cases. The cases are incomplete because we were not able to get complete information on these cases and we would like to identify the missing information and the procedures you follow to obtain such information or the procedures you follow in the total absence of such information.

Your analysis will be conducted in close interaction with us — please talk as much as possible. Ideally, we would not interfere in your thinking; however, we will encourage you to talk, if necessary by asking questions.

You should continue your analysis to the point where you can complete a PNM. We include a copy of AFLC Form 1612 (WPAFB Form 246) with each case to use, <u>in case you wish to do so</u>. You are welcome to use plain paper, if you wish (you may prefer an alternate form but it is unlikely that we will be able to procure it for you).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